EXPERIMENTS ON THE AESTHETICS OF LIGHT AND COLOUR

THIRD ARTICLE

COMBINATIONS OF COLOURS AND UNCOLOURED LIGHT

BY

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That the aesthetic value of colour is occupying more largely than ever before the minds of various classes of people can not be gainsaid. Not infrequently nowadays articles are published in magazines dealing with the effect of colour in some one of its different phases. In France recently tests were made in an insane asylum as to the effect of colour upon the inmates. It was found that a person violently insane was immediately quieted by being taken into a blue or violet room. Experts maintain that the decorations and draperies of living rooms have more or less effect upon the physical and mental health of the occupants. Whatever truth there may be in these statements, they at least show that the thoughts of more than one class of people are turned in the direction of emotional colour effects.

This should not be at all surprising since we know that the hedonic characters of the colour qualities are widely different. Not for bulls and turkeys, children and savages only, is red the most exciting colour, but it is so for grown up and highly educated people also, even if they show no outward signs of it. In the same way green is the most indifferent and blue the coldest and most tranquilizing colour; whilst in the purple and violet the cooling and quieting effect of the blue and the animating effect of the red combine to give the character of a grave and superior though somewhat uneasy dignity.[1] It is no mere whim then that makes us use green lampshades and decorations in our studies where we wish to give the mind the ease and rest necessary for concentrated work, whilst we prefer in our dining-rooms red wall papers on account of the animating and appetizing effect of this colour; nor is it merely accidental that a certain reddish purple is the colour of royalty and violet the episcopal colour. Æsthetically the colours between red and purple are extremely exclusive, so much so that almost nothing will harmonize with them except gold.

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[1] Wundt, *Physiological Psychology*, Fifth Edition, vol. II., p. 323.

That these things have, in practice, to be tried empirically is largely due to the fact that the popular ideas of colours in their variabilities are inadequate and unscientific and that the usual nomenclature is not only very incomplete but in many cases absolutely illogical. The scientific nomenclature is too simple; for all the qualities between green and blue we have no other designation than blue-green, green-blue, bluish-green, etc. On the other hand the names used in commerce are almost too numerous. Certainly they are inconsistent in so far as the "colour" does not refer only to the light impression, but very often also to the texture and other qualities of the material. This is so with regard to intensities; we call the slate of a blackboard "black," though it is scarcely as dark as some medium grey papers; if it is slate it is black; while if it is paper it is grey. We speak of black cloth, but a piece of silk or velvet which shows exactly the same intensity and light quality is called not black but grey; these materials in order to be termed black must be very much darker than cloth. Some of the colour designations can be applied only to material which has a lustre, such as silk and satin, others are dependent on the nature, roughness, or grain of the texture; others again refer only to reflected light, never to luminous bodies.

Gladstone and some German scientists once advocated the theory that the ancient Hebrews and ancient Greeks had not the fully developed colour-sense, and especially did not perceive blue and violet. This inference was drawn from the seeming poverty of the Greek and Semitic languages in regard to colour designations. Some hundreds of years hence it may be that our successors will not be able to understand how the colour terminology of our own day could have been arrived at, and how people could speak of red hair and tan shoes or ignore the difference in the light-quality of snow and the complexion of part of the human race, both of which are called white. But these are only comparatively insignificant examples of the inconsistency of our present nomenclature of light qualities. The greatest mistake made is that of mixing up saturation, intensity and colour-quality.[1] Magenta, rose and pink are regarded as different colour-qualities though they are only different tints of the same colour—a purplish red. They differ, apart from slight variations in colour-tone which do not appear in their names, only in saturation and intensity. In a similar way scarlet, cardinal and crimson are to be regarded as shades of red rather than as different qualities; by crimson is sometimes meant a blood-red, sometimes a royal purple. Cream is really a very light tint of orange. The so-called tertiary colours which usually go under special names such as olive, russet, pearl, etc., and are regarded as new colours resulting from the mixture of the secondary colours, are in reality nothing but ordinary colour-qualities with reduced saturation; thus if a greenish yellow is mixed with a colourless light of a certain low intensity the result is olive. Similarly if the saturation of orange (or reddish orange) is reduced by mixing with it much colourless light of the same intensity russet is obtained. As Dr. Kirschmann says: All these obsolete ideas of primary, secondary and tertiary colours are based on laws about colour mixture which were once approximately correct, when the decorative art had at its disposal only a few mineral colours of great purity, but which are, in the light of modern colour-chemistry, absolutely incorrect. There was once a time when the painter could say that a pure red could not be gained by the mixing of pigments; there was then no finer red than the mineral vermilion and the animal colour carmine, or the stained layer of the ruby glass coloured with cuprous oxide and traces of a certain gold compound. In our day, however, the most beautiful and spectrally the purest red which can be produced is the mixture of two aniline colours, an orange-yellow and a violetish-blue.

For some particular purpose a colour is given a certain name; the public is unable to distinguish between the name and the original colour and so takes it for granted that this new name implies a new colour. Only a few names of colours are original (going back to Aryan roots); red, yellow, green and blue may be so classed, but even these names may have referred to some objects at first. All other names of colours are derived from names—

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[1] Kirschmann, *Conceptions and Laws in Aesthetics*. (Univ. of Toronto Studies, Psych. Series, vol. I, p. 199.)

1st, *of fruits or other food:* orange, pea-green, cherry, strawberry, pistache, lemon yellow, olive, maroon, apple green, corn, café-au-lait, cream, melon;

2nd, *of flowers:* violet, pink, rose, heliotrope, wisteria, mauve, yucca, dahlia, primrose yellow, lilac, ivy, mignonette, grenat, moss rose, moss green;

3rd, *of other vegetable substances:* straw, sage, hazel (used only for women's eyes);

4th, *of metals:* gold yellow, steel blue, steel grey, red lead, copper red, zinc white, pepita (Spanish for nugget of gold);

5th, *of precious stones:* jasper, emerald, sapphire, turquoise, garnet, ruby, malachite, azure (lazur—lapis lazuli), pearl grey, pearl blue;

6th, *of other mineral substances:* terra di sienna, terra cotta, chrome yellow, chrome orange, terra verte, cobalt blue, mineral grey, umber, ochre;

7th, *of animals and animal substances:* sepia, crocodile, titiens (Antillean Warbler), fawn, ibis, llama, ivory black, canary yellow, robin's egg blue, elephant green, seal brown, dove, salmon, chamois;

8th, *of proper names—persons:* Bismarck (orange brown), Jean Bart (dark blue), Van Dyck brown, Van Dyck red, Rembrandt (red), Davy's grey, Payne's grey, Ophelia, Sappho, Victoria green;

9th, *of proper names—places:*—

(a) *countries and districts*—Gamboge, Quito, Egyptian, Labrador, Havana, Siam, Palestine (dull pink), Sauterne, African green, Helvetia, Magenta;

(b) *nations or tribes*—Italian pink, Judee, Zulu, Prussian blue, Chinese white;

(c) *cities, rivers or towns*—Nyanza (pale yellow green), Muscovite (sage-green), Naples yellow, Venetian red, Paris green, Solferino, Mablo yellow, Yale;

10th, *of other names:* Cossack (dark yellow green), mandarin, évêque;

11th, *of miscellaneous sources:* dragon's blood, lamp black, sea-green, khaki brown, ultramarine, nankeen, neutral tint, permanent white, mascot (very dark blue) (Fr. mascotte—witch);

12th, *of mythological characters:* Mars orange, Mars yellow, Pygmalion, Hebe.

This list is sufficiently extensive for our purpose but it is by no means exhaustive, nor is this variety of nomenclature likely to decrease.

The reason why up to this time there is no reliable source of information on colour æsthetics is that the multitudinous possibilities in colour combinations have not been taken into account.[1] Æsthetical laws have to be found empirically; mathematical deduction is only conditionally applicable and even then within very narrow limits. Investigation with the purpose of ascertaining empirically æsthetical laws has only begun, and the enormous task is still before us. The only experimental works on colour combinations are those of Jonas Cohn and Miss Baker, of which the latter seems the more important since Cohn has worked with too small a number of qualities and apparently relied with regard to complementarism simply on conventional statements. Both worked on binary combinations; Miss Baker's work refers to the colours in full saturation only and thus treats of a side of the question which, though fundamental, is not of great importance with regard to practical application; for it is scarcely ever binary combinations of highly saturated colours which we use for architecture, decoration or dress. The colours used for the purposes thus stated are mostly the so-called broken colours with here and there an interspersion of a saturated colour. The so-called broken colours, however, are nothing else than colours in diminished saturation and sometimes perhaps with changed light intensity. In other words, for practical purposes we seldom have to deal with fully saturated colours, but usually with shades and tints. Further, not only the qualities of the chromatic series are used for æsthetic purposes but also colourless light in its many variations of intensity. It is just the combinations of colourless light on the one side and the colours in their different saturation-degrees on the other which we have made the subject of an investigation, the results of which are unfolded in the following pages. These experiments were carried on during the academic terms of 1901, 1902 and 1903 in the psychological laboratory of the University of Toronto under the direction of Professor Kirschmann.

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[1] Kirschmann, *Conceptions and Laws in Aesthetics* (Univ. of Toronto Studies, Psych. Series, vol. I, p. 200).

The Prang colours in full saturation which Miss Baker used, and also the second shades and second tints of the same, were employed in these experiments. The room and apparatus were the same as those used by Miss Baker and described in her first article.[1] As representatives of the achromatic light the five greys of the Prang standard colour papers and the white and black of the Milton Bradley educational papers were used. They thus formed a series of seven intensities of uncoloured light. Unfortunately we can not claim that the intervals between them are of equal value. The distance between the darkest Prang grey and the Milton Bradley black seems to be greater than that between that grey and the next brighter one, though this discrepancy is somewhat mitigated by the darker background of black velvet which made the black paper appear only as a dark grey. A similar discrepancy is found at the other end of the series, the interval between the white and lightest grey appearing to be greater than that between the greys themselves.

Our method was the same as that of Miss Baker, the so-called "method of selection in serial comparison." When the colours of full saturation were used, two variations of the method were employed; at one time the twenty-four colours were constant (i.e., remained on the table) and the greys varied, and at another the greys were constant and the colours varied. In the one case the observer had the choice among twenty-four and in the other case among seven combinations; with the tints and shades, however, no such chance was given, the choice always being from the twenty-four.

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[1] University of Toronto Studies, Psych. Series, vol. I, pp. 205 etc.

All observations were made in the early hours of the afternoon, in a large room (the old Ethnological museum) which is lighted by a skylight almost the size of the whole ceiling, and is thus provided with most favourable illumination. There were twelve observers, but in the following record only the results from eight of them are given; these, however, completed the following series twice:—

1st. A comparison of the combinations of fully saturated colours and greys—

(*a*) Greys constant,

(*b*) Colours constant.

2nd. A comparison of combinations of tints and greys—tints always constant.

3rd. A comparison of combinations of shades and greys—shades always constant.

Duplication was necessary in order to secure some criterion for the consistency of the observers' judgments.

The fully-saturated colours were designated by the numbers one to twenty-four as in Miss Baker's article.[1] In the case of tints the numbers had the index t, in the case of shades the index s. Thus 7 means yellow orange in the fully-saturated colours, 7t means the second (according to Prang) tint of this colour, and 7s similarly the second shade. The members of the achromatic series were designated by the numbers one to seven, black being one and white seven. The intensities of the different greys, according to photometrical measurements reported elsewhere in this number by Mr. Smith,[2] are as follows:—

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[1] Univ. of Toronto Studies, Psych. Series, I, 221.

[2] *Infra*, p. 36

[illegible]

[illegible] at one time. Finally [illegible] and IV are combined.

Since tables containing so many numbers are not very perspicuous and cannot give at a glance any idea of the [illegible] of the result of our work, it was thought advisable to [illegible] Plates illustrating curves which are more easily surveyed. Plates I to IX are intended to fulfil this requirement. Each of the Plates I to VII graphically represents the results for one of the [illegible]; the lower figure denotes intensities of the [illegible] light, the [illegible] refers to [illegible] the middle one to the colours, and the upper to the tints. There are in each figure two curves, the upper one representing the pleasant, the lower one the unpleasant judgment. On the abscissa line are represented the twenty-four [illegible] and the length of the ordinates corresponds to the number of judgments.

In Plate I the combinations [illegible] and blue are represented [illegible] the most pleasant [illegible] blue [illegible]

[illegible]

[illegible] of the curves [illegible] red and [illegible] experiment [illegible] complementary [illegible] red and blue [illegible] combination is by no means complementary [illegible]. It may be interesting to note the fact that blue and red were found to be complementary in a case of [illegible] colour illusions described by Kirschmann[1] and that Dr. Lane[2] showed that the most favourable condition with regard to the space threshold exists not between complementaries, but between red and blue.

The question may be asked, what is the cause of the decided advantage which the red and blue have? It might be said that this is a peculiar property of the Prang colours, that the red, blue and violet are especially saturated or especially mild. But a close examination of the colours with regard to

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[1] Philosophische Studien, vol. [illegible]

[2] University of Toronto Studies, Psychol. Series, [illegible]

[illegible]

[illegible]

[illegible] feeling and impression are [illegible] that people can come to the conclusion that [illegible] to a [illegible] extent unpleasing [illegible] *[illegible]* For some amount of contrast seems to be necessary for the production of a single aesthetic effect, be it through [illegible] either similarity of saturation or intensity of the [illegible] tone.

Of the two minima we [illegible] the one in the yellow and green is more decided than [illegible] that in the purple. [illegible] throughout is far deeper in the yellow green than in the purple, and in comparing the curves it will be easily noticed that the gap covering the middle of the spectrum is broadest in the curves for black and narrowest in those for white. It may also be observed that in combination with black and the darker greys the maximum in red has a slight advantage over that in blue, while in the combination with the lighter greys and white, especially for the tints, the maximum in blue has the superiority.

It is quite characteristic that though the maxima are not considerably higher in tints than in shades, yet the forms of the curves show marked differences. The rising of the curves near the maximal points is steeper and more abrupt for the shades, while the colours and still more the tints, especially for the maximum at red, show a certain rounding off. This is visible in all curves, but the higher the intensities of the greys the less marked this difference becomes. The minima of the curves are not quite as uniform as the maxima, though they are always to be found in the yellow, green and purple; with the increase of the intensity of the grey the minimum regions seem to broaden somewhat and also to shift toward the right, i.e., from the yellow to the green.

In regard to the area which the curves enclose and which is an exact measure of the capacity for harmony of the grey in question, we may refer back again to our table. The numbers at the bottom of the columns are representative of these areas, and the number designated "Gr. T." gives always the pared total for the whole table. From the summing up we see plainly that for the [illegible] as well as for the colours and the intermediate [illegible] [illegible] in the experiments [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] see that combinations of [illegible] [illegible] [illegible] the pleasantest combinations [illegible] grey and black. From the separate [illegible] [illegible] results [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] with [illegible].

The total [illegible] [illegible] for the [illegible] [illegible] for that. The [illegible] [illegible] pleasant [illegible] for [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible] that these [illegible] [illegible] of the [illegible] and the [illegible] of the colours and greys. Consequently the [illegible] in Plates VIII and IX [illegible] [illegible] the [illegible] plate.

As [illegible] above, the experiments with the colour [illegible] combinations were carried on in two ways: in the one case the colours were constant, in the other the greys. Since we have here a selection from twenty-four on the one hand and only seven on the other, the two cannot well be compared. Table IV gives the results of the experiments where the greys were constant, and in Table V the totals for the colours in full saturation are given, confirming the results of Table I with regard to the colours, but not altogether with regard to the greys, for the maximum of pleasantness seems to be with the medium greys and not with the black. Corresponding to Table V we have drawn the curves in Plates X and XI, of which the former refers to the unpleasant and the latter to the most pleasant combinations. In order to gain space we let the [illegible] of the curves overlap to some extent, to facilit to the understanding of the curves: the designations Black, Grey I, Grey II, etc. are attached not only to the curves but due to the place of their respective characteristics. These curves again show plainly the maxima for the colours two and seventeen and eighteen, a pronounced minimum for the yellow-green, and a somewhat smaller depression over the violet-purple. The [illegible] combinations [illegible] especially [illegible] in the medium grey.

Summary

I. In combinations of coloured and uncoloured marks of equal shape and size the more emotional colours, e.g. the so-called warm and cold colours, have [illegible] especially [illegible] advantages. The best combinations are obtained with red and [illegible].

II. Tints [illegible] to harmonize more easily with colourless light than colours in full saturation, and these more easily than darker. Nevertheless the most agreeable combination is mostly obtained with full colour and black. (See [illegible] curve.)

III. The emotionally indifferent colours, yellow, yellow-green and green, and to a lesser degree violet and purple, also furnish with uncoloured light indifferent or even unpleasant combinations, and the more so, the less light intensity the components show.

IV. The much discussed but experimentally never verified assumption of the aversion to yellow probably has its foundation in the fact that yellow does not harmonize easily with colourless light.

[illegible]

Black	Gray I	Gray II	Gray III	Gray IV	Gray V	White	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Grand Total—1343 Pleasant; 235 Most Pleasant

[illegible]

Grand Total [illegible]

[illegible] III. [illegible]

[illegible]	Storm I	Storm II	Storm III	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

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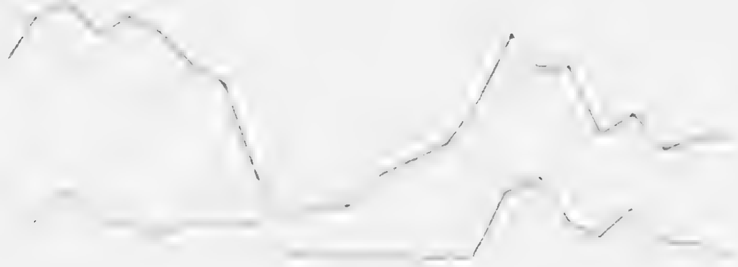
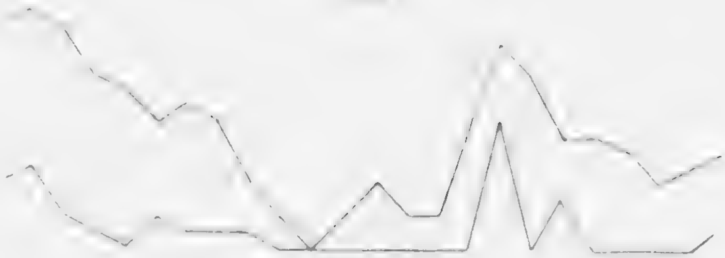
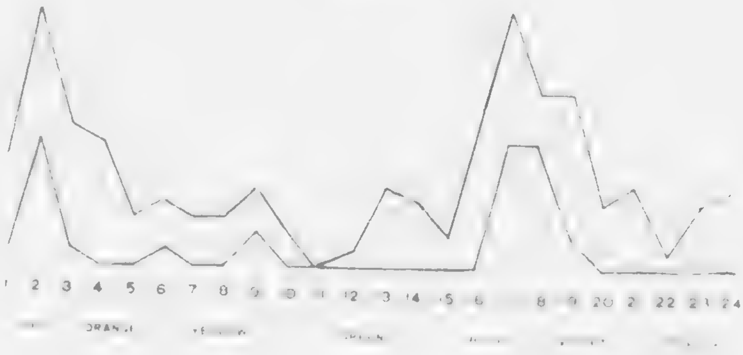


TINTS

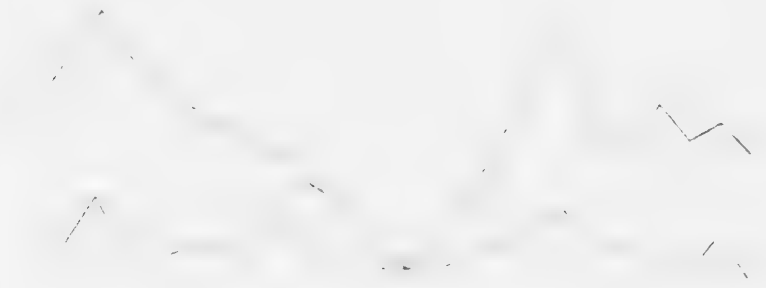


COLOURS

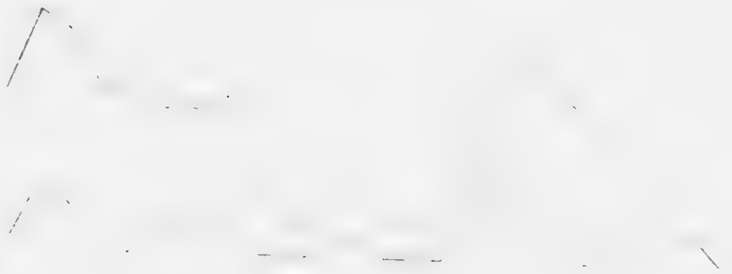


SHADES

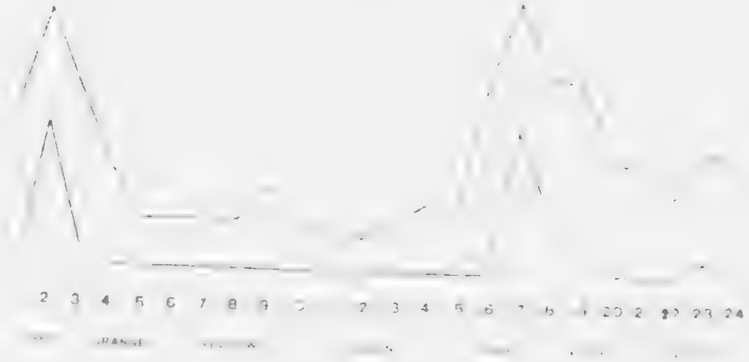
PLATE I. BLACK



TINTS

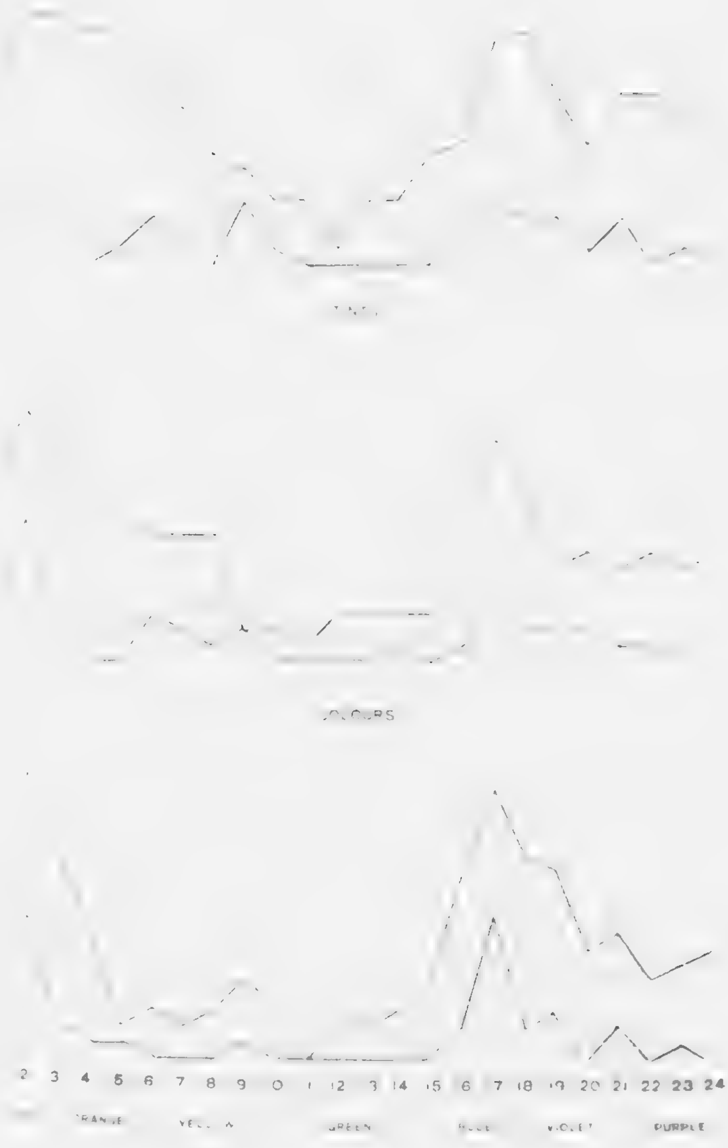


COLOURS



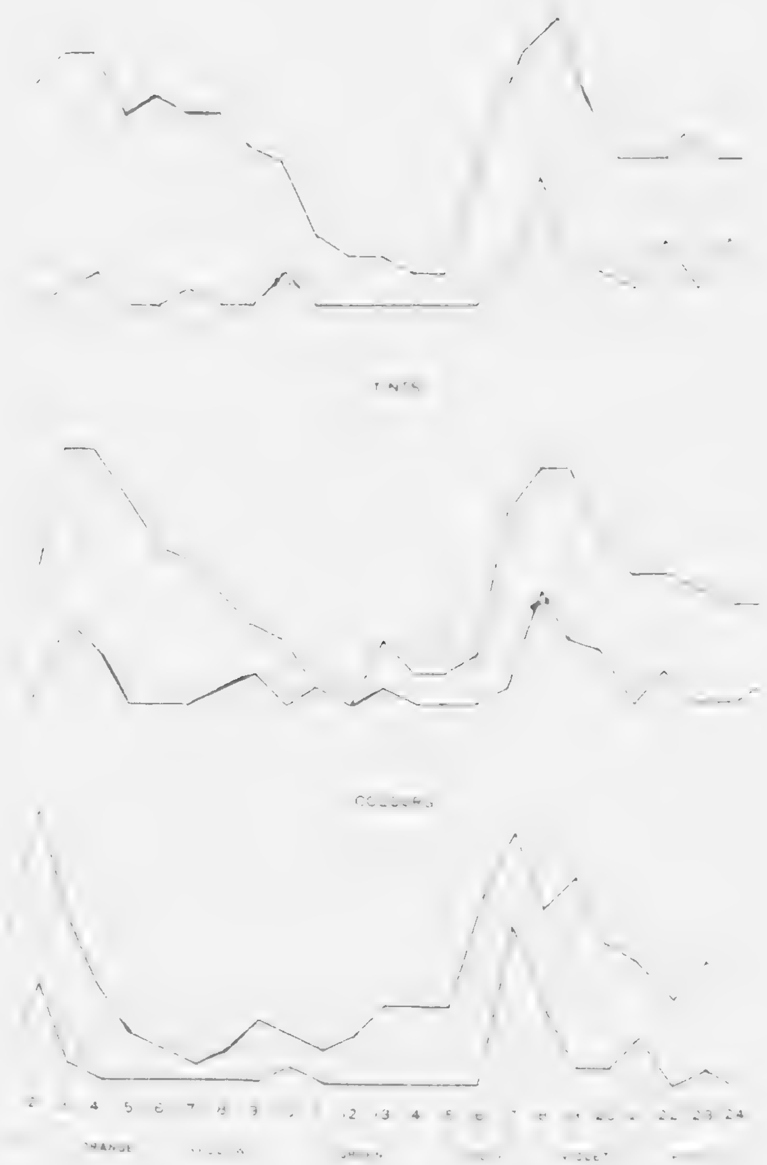
SHADES

PLATE II. CURVES



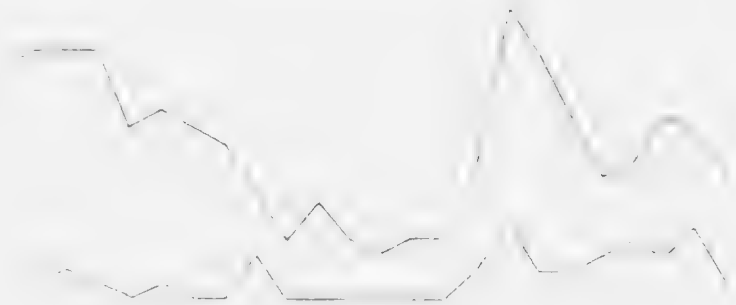
SHADES

PLATE III. GREY II.



SHADES

PLATE III. GREY III



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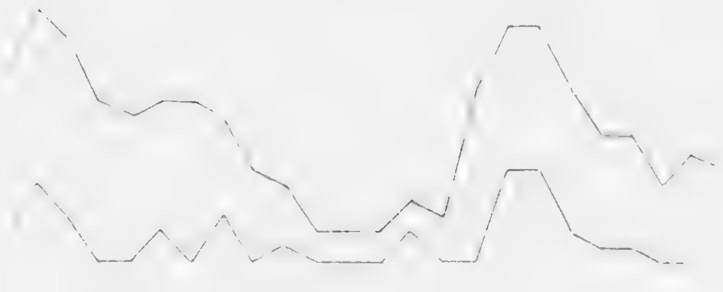
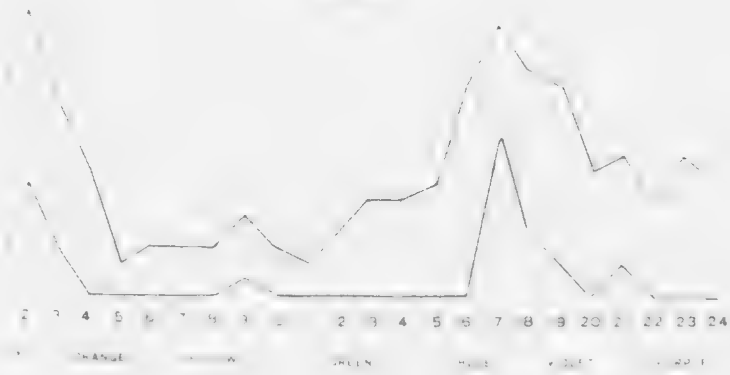
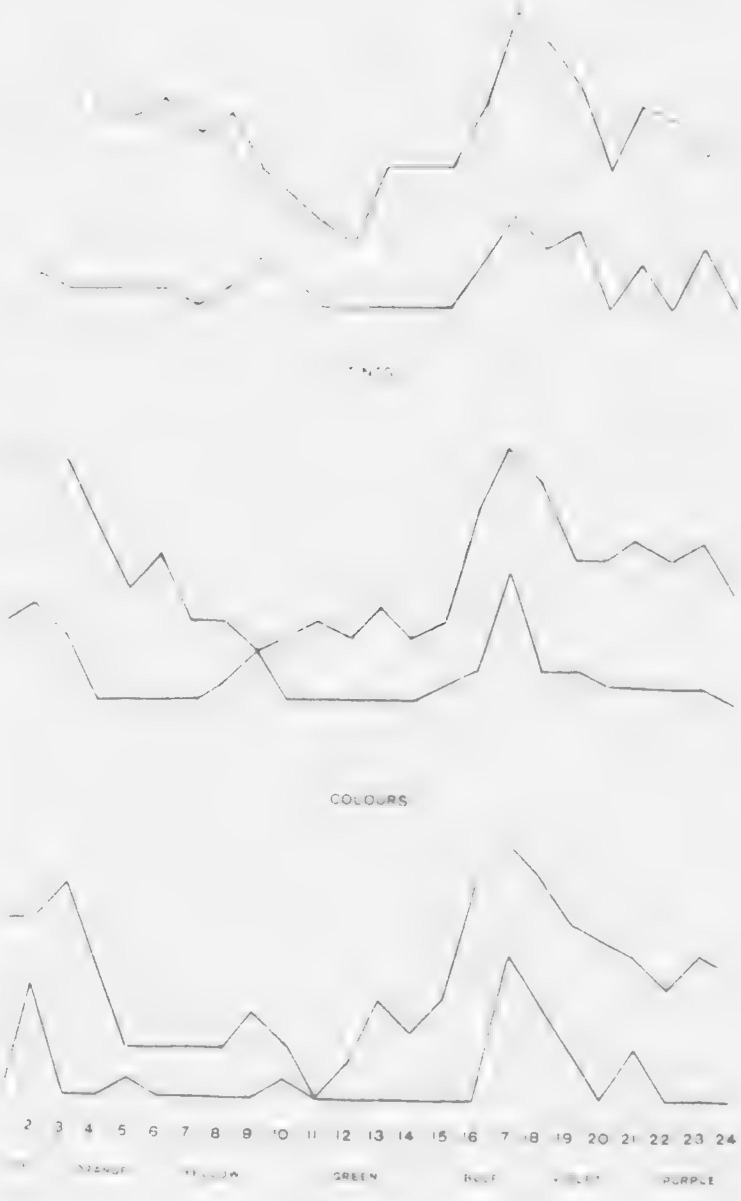


COLOURS



SHADES

PLATE V. GREY IV.

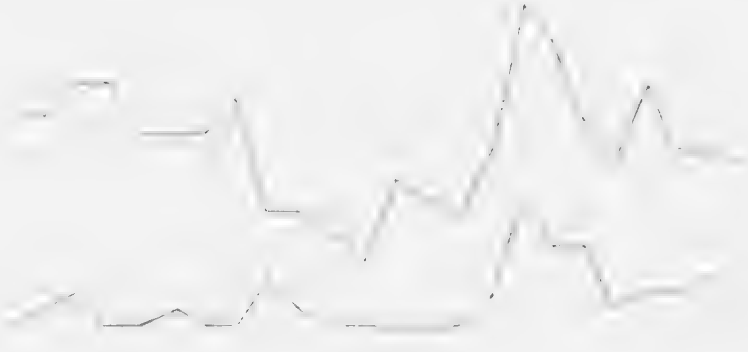


TINTS

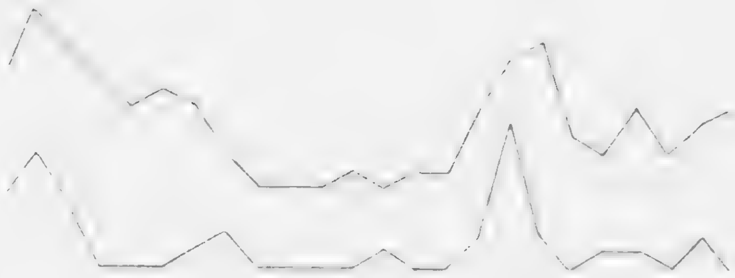
COLOURS

SHADES

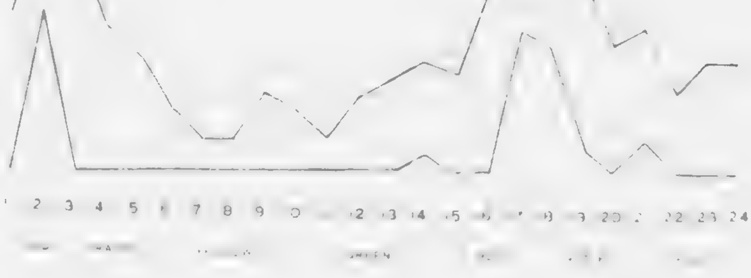
PLATE VI — GREY A



TINTS



COLOURS

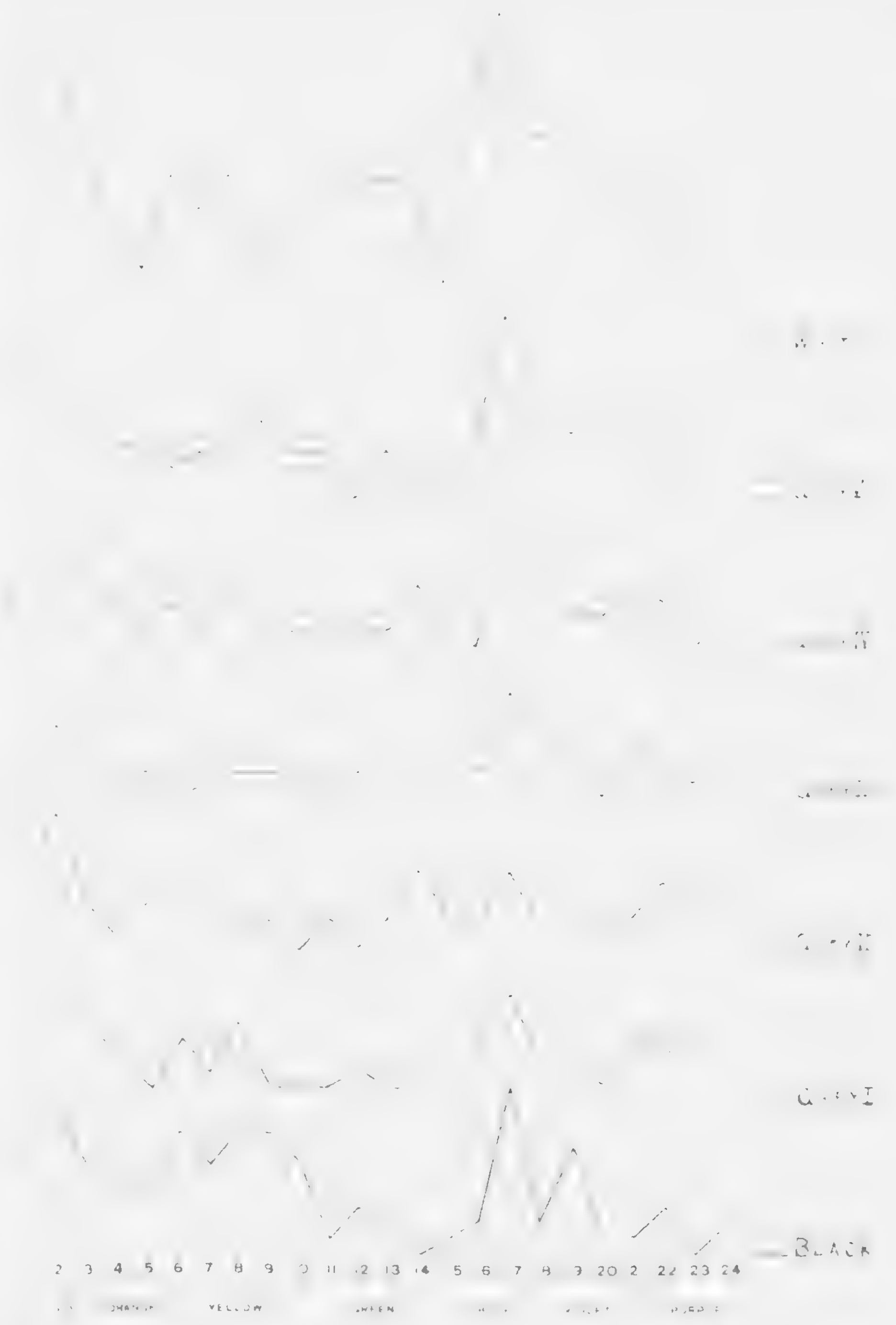


SHADES

PLATE VII. WHITE

PLATE VIII. COMBINATION CURVES

PLATE IX. TOTAL COMBINATION CURVE



X MOST PLEASANT COMBINATIONS COLOURS TOTAL

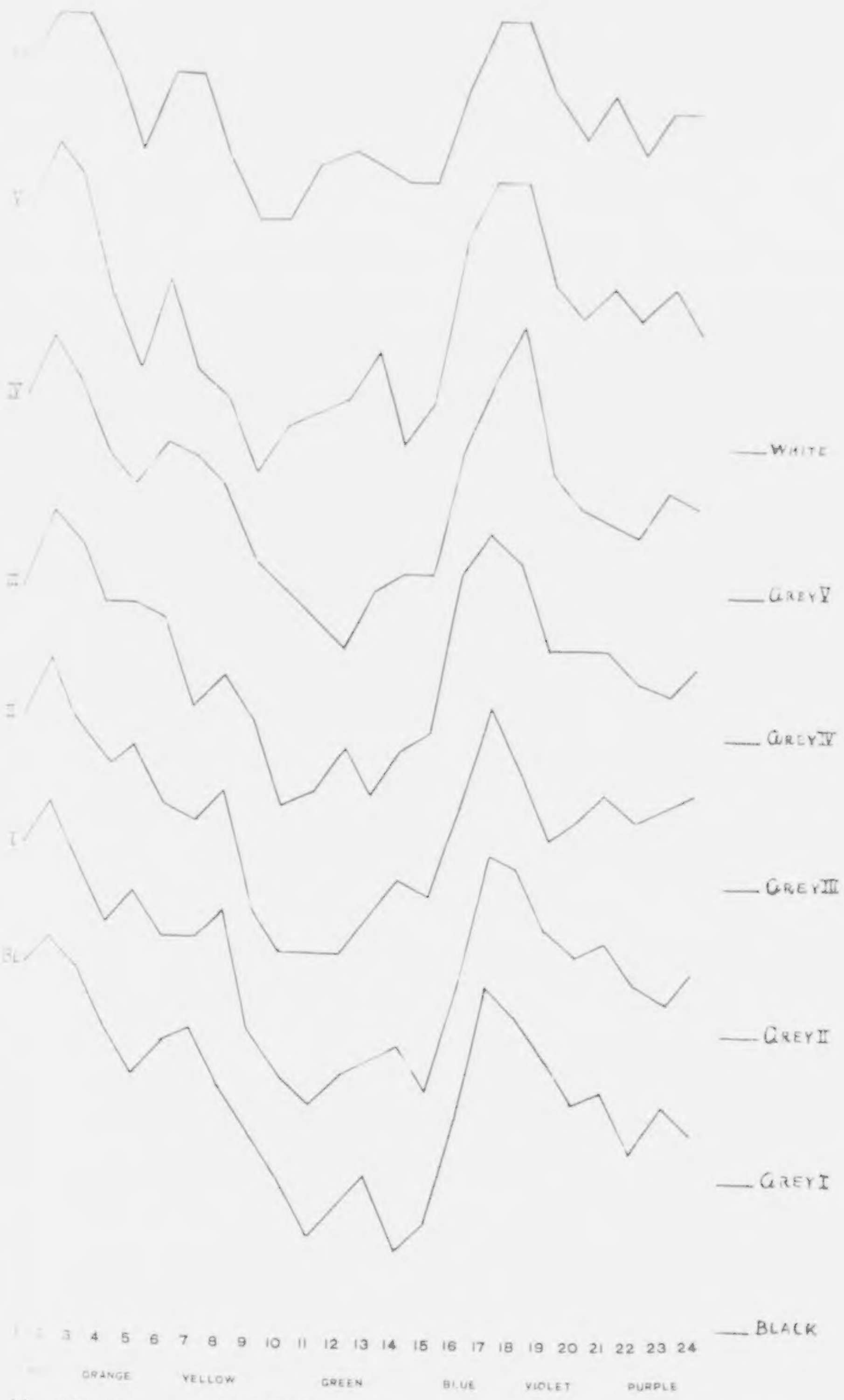


PLATE XI.—PLEASANT COMBINATIONS—COLOURS (TOTAL)